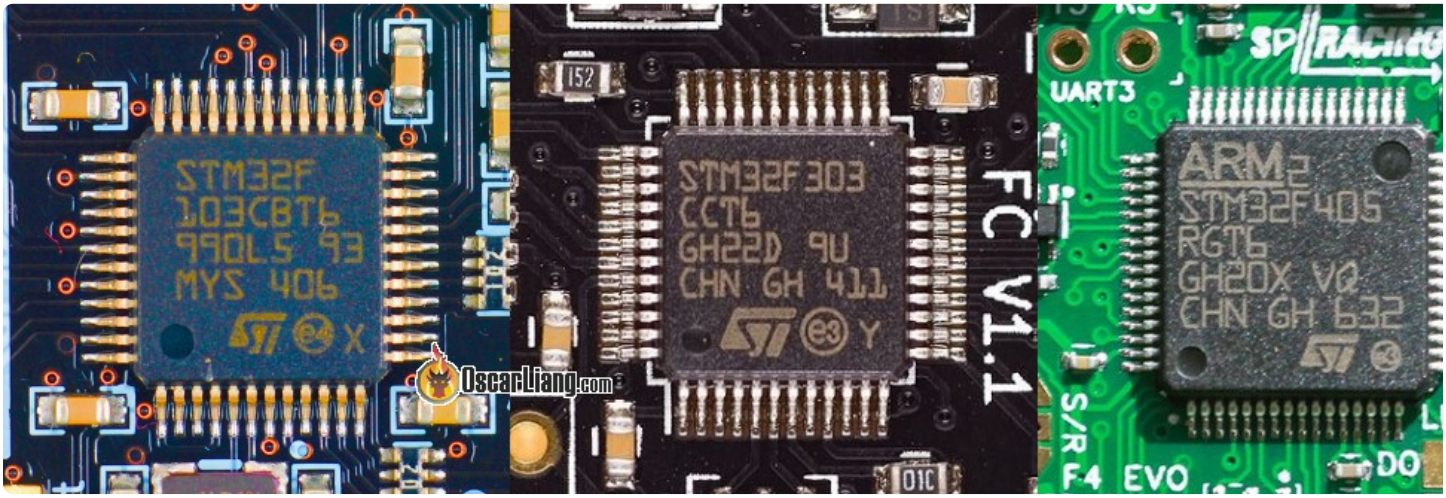
F1, F3, F4, G4, F7 and H7 Flight Controller Processors Explained

Published: 30th December 2021 | **Last Updated on** 22nd March 2022



F1, F3, F4, G4, F7 and H7 are the different processors in FPV drone flight controllers. This article expl differences between these MCU, the pro's and con's, which I hope it will help you decide what FC to g

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Table of Contents

1. What are F1, F3, F4, G4, F7 and H7 in Flight Controllers?
2. F0
3. F1
4. F3
5. F4
6. G4
7. F7
8. H7
9. Differences between F1 and F3 Flight Controllers
10. Differences Between F3 and F4
11. Benefits of F7 FC over F3 and F4
12. So, which processor should I get?
13. What happened to F2, F5 and F6?

What are F1, F3, F4, G4, F7 and H7 in Flight Controllers?

F1, F3, F4, G4, F7 and H7 are the different STM32 processors (aka MCU – Micro Controller Unit). The
or is the brain of a flight controller (FC), similar to the CPU in a computer.

STM32 F1, F3, F4 processors on flight controllers

Processor (example chip)	Processor Speed	Flash Memory*
F0 (STM32F051K8)	48MHz	256KB
F1 (STM32F103CBT6)	72MHz	128KB
	72MHz	256KB
	168MHz	1MB
	100MHz	512KB
	170MHz	512KB
	216MHz	1MB
	216MHz	512KB
	216MHz	2MB
H7 (STM32H750)	480MHz	128KB
F7 (STM32F722)	216MHz	256KB

F0

F0 is often used in BLHeli_32 ESC, however it's too slow / has too little memory for flight controllers. I I would mention it anyway.

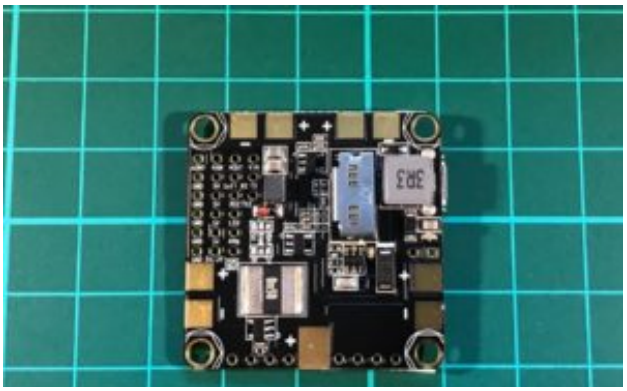
F1

The first 32-bit flight controller ever used on a mini quad was the CC3D which had the F1 processor (F The other iconic F1 FC was the Naze32.

However F1 flight controllers are considered outdated as they are no longer supported by most firmwa including Betaflight (since 2017) due to hardware limitations – low clock speed, not enough memory fo storing the firmware, lack of floating-point acceleration hardware and UART's.

F3

F3 processors (F303) were first introduced to flight controllers in 2014. It's more powerful than F103, a e obvious choice to replace F103 as they are pin-to-pin compatible. Some advanced users ev



Betaflight F3

F4

F4 flight controllers were introduced shortly after the F3, and quickly gained popularity due to its proce

ay well with Frsky receivers, as they don't have build-ir

cking) is required for Frsky SBUS, SmartPort and F.Pc

05 and F411.

find this in 30x30mm flight controllers.

itecture with F405. However it has lower CPU speed, f

this in whoop style FC, 20x20mm or 16x16mm FC.

nba F405, Matek CTR AIO, FlightOne Revolt and Brai

as the largest memory, it's the newest chip used in fligl
7. The first G4 flight controller is the KISS G4 flight cor
made by Fettec, released in October 2021.

It's a better replacement to the F3 and F4 MCU, even more useful as we are currently in a chip shortag
es with a math accelerator for enhanced flight performance and has better power efficiency.

Just like F4, there are a few different variants for the F7 MCU.

STM32F745 is a common F7 processor in FC, very decent clock speed and memory, however it also h pretty large package, so if there is a lot of feature you want to have on the FC, the F745 probably woul

STM32F722 is a smaller F7 MCU but with less flash memory and RAM, still it's enough for the current Betaflight. In fact the F722 is the most popular F7 chip in flight controllers as they are also cheaper tha

STM32F65 is the most powerful F7 processor used in FC, in almost every aspects. However it's even and more expensive than F745, therefore it's not a very popular option.

There are more options of F7 flight controllers than F4, for example the Kakute F7, CLRacing F7, Beta F7 FC and SP Racing F7.

Seriously Pro Racing is the first to release a flight controller with H7 processor – the H7 EXTREME. It' on STM32H750 processor providing a 480MHz clock speed, compared to 216MHz of the F7.

However the higher clock speed doesn't make a difference in flight performance as we speak. We still room to grow with F4 and F7 flight controllers, it will certainly come in handy when we start doing 8KH looptime with RPM filters alongside other calculation intensive features in the future.

However the SPR H7 Extreme uses the cheapest and smallest H7 chip – the STM32H750, which only 128kB of flash memory (same as the F1). And that's really not enough to store the current Betaflight c work around this, they store the Betaflight code on external memory, i.e. on an SD card. The codes are loaded to the RAM when it's running (and so it doesn't matter even when SD card falls out during flight

To update Betaflight firmware, you will just update the firmware files on the SD card, no more flashing

ound of it, and therefore I don't recommend getting it j

3 Flight Controllers

ges over F1:

vever the F3 is better at handling floating point calcula "). This allows an F3 to run floating point based PID so you can run faster looptime on F3 than F1

o the 3 offered by an F3. In addition, and possibly mor ed USB port. It was common for users of F1 boards to connecting any peripherals to UART1 in order to retain this slot for PC connection. In reality this r that an F1 board has only 1 UART for additional hardware, whereas an F3 board can usually utili RT's for extra devices

Note the size of flash data storage used for Blackbox logging doesn't depend on the processor. It's actually determined by a separate memory chip on the flight controller.

Differences Between F3 and F4

- The **processing speed** of the F4 processor is more than double of the F1 and F3 (72MHz) at 18
while it also commonly has a dedicated FPU which is what gives the F3 the advantage over the F
- It's possible to run **32KHz Looptime** on a F4 board compared to the Max 8KHz on an F3
- F3 boards generally only have 3 UART's, but some F4 FC's offer up to 5
- Betaflight's new feature "Dynamic Filter" is very labour intensive for a processor, giving the increa
speed of the F4 another clear advantage

inversion like F3 and F7. Without additional hardware
ack (getting uninverted signal) if you you want to run F

*different discussion. Check out this article about whe
ance.*

*the S.Port wire is bi-directional that data is sent and
same time, that's why it's only "half").
protocol internally in the chip itself, so you can conne
SmartPort directly to these flight controllers without any modification. But F4 doesn't have this capa
Although SmartPort is also inverted, F3 and F7 can invert the signal coming in or going out interna
roblem there.*

platform for future flight firmware development, allowing the developers to further optimize the flig controller algorithms

- F7 boards allow for more UART's, all with built-in signal inversion capability. Considering all the peripherals that we can use nowadays – serial receiver, Betaflight OSD, SmartAudio, SmartPort Telemetry, GPS, Camera control etc, DJI OSD, Blackbox logging, more UART's are always handy have!

At some point, It was necessary to overclock F4 if you want to run 32KHz in Betaflight, while the F7 pr is fast enough to handle 32KHz without overclocking. That shows you how important that extra proces power could be.

Looptime is also limited by the type of gyro (IMU) and their maximum sampling rate. For example MPU ou want to do 32KHz, you would have to use IMU with 2.

os in their F7 flight controllers. One is the proven, low aster gyro that can do 32KHz such as the ICM-20602. ant to use.

get?

Here are my FC recommendations.

with an older F1 board (with older firmware), but you w certainly get better performance and more features from a modern flight controller with update to firmw

We can anticipate technology moving toward faster processors, which will provide capacity for more ex and peripherals, and the capability to run more sophisticated filters and algorithms that can re

latest Betaflight firmware.

Update (Feb 2019) – Betaflight developers announced to drop support for F3 FC in Betaflight 4.0 d the lack of memory.

Yes, H7 is the latest and greatest, but in my opinion, it's still a bit new to be considered seriously. I'd personally wait until a few more manufacturers start making it, and the Betaflight code is a bit more op for that platform first. So far there is really no real benefit of switching over to H7 just yet.

So really, the decision is now down to F4, G4 and F7, all are good options today, but in my opinion, the the following advantages:

- en running Dynamic filter and RPM filter, and with othe sly
- n F7 than an F4 FC
- , but if you are, definitely get an F7 because all the UA rtPort. It's a lot easier to set these up than on F4
- updates and improvements (more future proof)

cations of all FC's for mini quad in this spreadshe ou can compare them more closely.

What happened to F2, F5 and F6?

STM32 chips we have seen used in flight controllers are F1, 3, 4 and 7, those who have a cu

STM32 F5 and F6 simply do not exist.

Edit History

- Oct 2015 – Article created for F1 and F3
- Oct 2016 – Updated F4 info
- May 2017 – Updated F7 info
- Jun 2017 – updated news about “Betaflight will end support for the F1 FC”, and added a column f memory in the table thanks to Boris B.’s idea
- Aug 2017 – updated info about the missing F2, F5 and F6
- Oct 2017 – edited by Tom BD Bad, info about some F7 FC having 2 gyros
- Oct 2018 – updated my thoughts about F7 FC

upport for F3 FC

F4 and F7 chip variants

BEGINNERS FLIGHT CONTROLLER

r

Review: Happymodel Crux3 NLR (1865 Long

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SUBMIT

77 COMMENTS

C ULTRA to H7 section.

ompatibility using an F4 processor? Why can't I find D

27th February 2022 - 1:35 pm

There's a chip shortage, manufacturers are currently having a hard time finding aff F7 chips. That's why many are now using H7 and G4 chips as well.

good enough in a near future. especially for boards with built-in SPI ExpressLRS receiver.

SERGEY LARIONOV

30th August 2021 - 12:59 pm

Your flight controller table is great! But I build model airplanes. Is there a similar table for fix flight controllers?

VICTOR WILD

15th January 2022 - 2:32 pm

Excellent and immediately understood,but can you tell me why my Matek F722 an ow a Crossfire Nano receiver working in the receiver t connect an ELRS receiver, which is connected in the s TX to RX and RX toTX) with the port and receiver tabs ers are working as shown by return telemetry on the g to find a solution to this problem for weeks and am a to the overpriced Crossfire receivers.

Extreme runs at 400 not 480 MHz. The benefit of that particular FC isn't about having the fastest controller but rather a true sensor fusion techno that Betaflight 4.1+ can utilise. Faster processing is needed to handle two gyro data stream be able to run multiple RPM, dynamic and other filters at high rate.

I would consider and recommend that particular board for its near perfect low noise level, h

20th July 2019 - 11:41 pm

Hello Oscar,

Good day

I always read your post for guidance and to get some expert's knowledge I am new to this h started building a plane using Mini Talon with Matek F22 Wing. While soldering the pin hea accidentally snapped one component it's the 6 pin black thing on the upper right corner of S slot I don't know what it is. Can you help me figure out as I need to replace it. Can you also about this F7 flight controller. Thank you

Regards,

AL

the wealth of knowledge you compile and share with c
n, I am building a drone controlled by a computer inste
ds to a pixhawk FC via UART from an onboard compu
uggest (with beta flight or clean flight onbaord) that ca
roll angles or rates via uart instead of sbus? or is
nand simple pitch/roll angle or rates, and its not possib

OSCAR

15th July 2019 - 4:33 pm

No, not possible.

better on 4.0 but it also needs more resources (memory and CPU) which are limited on F3

JON SCOTT

29th May 2019 - 12:47 am

Hi Oscar, would love to know if these faster FC's use much more power, MORE POWER (a would say), or is it in significant. Seems to me that the NAZE32 with good software are as g you need for park crashing and this faster Hz speed is smaller legs running faster. Cooler electronic run, the better and longer they last.

OSCAR

30th May 2019 - 5:11 pm

FC is negligible in a 5″ quad.

ng propellers on a tail sitter platform like Pogo. Can yo orm?

a stabke release i can use on them CF or BF doesnt m

From what i remmber i think that CF 1.11.0 or 1.13.0 were stable on F1, can you confirm ? recommend ?

Oren

Still what I canot find on the web is a list of stable release (BF or CF) for each of the legacy i.e. F1 and F3.

I have many old parts which i want to make usable again, but i dont know which one of the releases where stable (best) for the F1 mcu.

Currently new versions that I have installed on F1 mcu looks unstable on the F1.

From what i remmber i think that CF (cleanfligth) version 1.11.0 was good for F1.

Some other say that 1.13.0.

I think it would be use full to share stable releases for old equipment.

Thanks Oren

CHRIS

years ago, and its still super useful, thx!, lol.

ible to flash betaflight 3.5 on to kiss version 2 F7 stm3

Target under betaflight Target list

no I don't think that's possible yet.

ANDREW

23rd March 2018 - 8:25 pm

What is the power consumption of of FC? A little chart would be good showing load and idl wattage at 5v.

CHRIS C

14th December 2017 - 5:05 pm

You mentioned the “Dynamic Filtering” feature a bunch of times. What exactly is it? Also, w you need to do if your UART doesn’t invert automatically like on the F4?

CHRIS

9th December 2017 - 12:04 am

copter? If so, what pins do I solder the signal wires to

named from Cortex M0 – M3 M4 core family directly b

12th December 2017 - 1:53 pm

LOL you are right! i got confused there!

difference in flight?

With duplicate rates.

OSCAR

28th November 2017 - 2:15 pm

If you use Dynamic Filter, you would be only able to run 2K/8K looptime at most i t

Whether you can notice a difference? that's hard to say!

IM UK

20th November 2017 - 2:52 am

g. Although ST is very low tech than Samsung here, I

the same process.

ning slower in betaflight 3.2 then F4 processors right n

now about other flight software though.

t…

I'm Looking for a board to my quad QX9 frame. Maybe some F4 with OSD and Current ser

Thanks for help

F4 (YOU MEANT F3) leaves you with less CPU load to run other features. Especially now
latest “Dynamic Filter” feature which is quite processing intensive, F4 definitely has an adva
in that regard going forward

OSCAR

21st August 2017 - 2:36 pm

LOL I think that’s an misunderstanding, I mean to say F4 can have a lower % of C
so it can run more features at the same time.

BORISB

21st June 2017 - 12:56 pm

from F3 vs F1, (256kb vs 128kb) which plays a huge
developed on that platform ;)
to fit any of the modern features on F1;s

y good point! I have added a new column now in the t

I have a wizard x220 with the FS-16 tx. It came with the F3 6DOF fc. It came from banggoo
yaw problems. In the process of attempting to correct it with beta flight lost factory settings
Any help on binding it to the FS-IA6B receiver? any help is greatly appreciated. First racing

You should have got a bind plug with your setup, plug the bind plug into the RX ch
ppm I think it is, power quad up, now with your finger on the bind button switch on

GARVIT

5th October 2016 - 7:49 am

Hello, I am thinking about making a quadrotor with contra-coaxial motors or a simple hexa
have a mission, but will be flying with RC only. My query is, at the time of selection what ar
parameters of the vehicle that needs to be considered? Also, motors or size of the vehicle
weight, etc., anything like that needs to be considered while selecting the FC? Please sugg
an FC for the given requirement and I want FC with lowest integration required to be done
one whose coding can be done easily or easily available online.

n.

vs and articles a lot.

as a few F3. I experience drifting problem sometimes
des…

but not too expensive.

otolab cyclone??? Anything else? Lot of choice nowad

Anyways thanks for soir work…

OSCAR

23rd June 2016 - 3:51 am

Hi Oscar

I was building my first quad using the sp racing f3 acro and manage to damage the + vbat

The board works fine when plugged to cleanflight but I get nothing when plugged to a lipo..

I already resolder everything and nothing changed so i tried plugging a lipo directly to the v

pads and still nothing..is there any other way to power the board other than the vbat pads?

But away thanks your videos and blog have been really helpfull..

CHRIS

6th September 2016 - 6:35 am

I believe the one red wire coming from number 1 esc will power up your board no

om the vbat pins, they are for the board to read the ba

via an OSD or allow you to set up a buzzer to warn yo

powered from either a 5v BEC which may be built int

rom an ESC if the ESC has a BEC. You will be able to

oming from it to a servo plug. You then supply the boa

ow of ESC connections and a ground to any pin on th

you have the soldered vertically).

RUSSELL HOLT

16th June 2016 - 7:14 pm

dropouts.

when i asked about data, i was given information that related to the F1 that had data dropo was hoping that using SS on an F3 would probably be an improvement over the F1 being t calcs were faster & therefore could maybe handle the interrupts (if that's what they're calle the GPS without a problem.

btw – appreciate all you do for the Quad world – i've referred to & made use of several of y Discussions, Videos and "blogs" – thank you.

Russ from Coral Springs, Fl USA

NICK

29th April 2016 - 11:04 pm

acing f3.. Cuz I want to support the designers … Anyw e weeks a small branch jumped out at my quad.. Vooc et… Nothing close to the torture I put my poor naze 32 d just dropped mid flight like a sack of potatoes… Afte issing from the board… After many many attempts to n my sbus reciever off one of the other uarts… I was r eks spare time to search rcgroups…. So after a couple mistake… I had to install software from Queen flight t est firmware which took two days to figure out how to d y to tell me how did I needed to do that so Massive Rc o tell you how to do that so I did it I updated the board not connect I had to go back in uninstall all three prog that I could connect to the board after all of that it would not read my receiver it is now sittir the floor in the corner of my junk file I bought in a F3 copy that has worked in my quad thro crashes and works just perfectly just FYI

Let's eat grandma!

Punctuation is very important.

DERRICK

30th October 2016 - 1:13 am

I had ripped off those aswell, and its micro soldering. but u can solder wires directl

those tiny metal pieces. at least I did to get Xbox working again.

BRYAN

24th December 2015 - 2:25 pm

Oscar

ing again and again that you have the best quad info r

g from you guy

n, Merry Christmas to you too :)

Hi Oscar.

To add to the conversation. There is RaceFlight for Revo, Revo Nano and Sparky 2. A Beta

Port.

Hi Oscar

If I was to spend more than $30 for a FC I would not buy an over expensive F3 to run betaf
I would just buy a revo mini for $45 with F4, it's cheap, it is supported by several FC softwa
has the power and the hardware for the features++ and it's already ready for the improvem
2016 will bring.

take off the blinders guys ;-)

OSCAR

3rd December 2015 - 12:59 pm

you got a point there my friend :)

p up the good work, Sir.

15th November 2015 - 11:15 pm

Hi Oscar. Is SPR F3 board from BangGood an original one or fake copy? Price seems to b
will it run betaflight ??

Sorry I don't know! I wouldn't be surprised if it's a fake copy as these things are no
to reverse-engineer and clone… maybe check with Dominic Clifon.
Anyway i think you should get the genuine board to support the designers. :)

MICHAEL

16th November 2015 - 5:20 pm

Hi Oscar
Dominic Clifton is reading your blog and could have a look.
Here is a link. 2 versions available 6 and 10dof called acro and deluxe
http://www.banggood.com/Upgrade-NAZE32-SP-Racing-F3-Flight-Contro
6-DOF-10-DOF-for-Milticopter-p-1010232.html?p=OY2106728901201408
and pictures looks much better than my existing F1 fli

ber 2015 - 10:21 am

d me it's an unauthorized clone, and they probably us
ossible components so it should be avoided.

MICHAEL

17th November 2015 - 1:11 pm

Hi Oscar

OSCAR

17th November 2015 - 1:46 pm

it's widely available, just google it.

DOMINIC CLIFTON

11th November 2015 - 2:24 pm

So much dis-information and FUD in the article and replies.

F3 has newer CPU core. Yes it's 72mhz still but it gets more done and not just because of t

FPU.

-m/cortex-m3.php

-m/cortex-m4-processor.php

SC1169/SS1031/LN1565

SC1169/SS1576/LN1531

more is done in hardware. The F3 also has USB bootl

nore cost.

nany other small differences that make the F3 a better

Hi Dominic,

This article focus on what benefits a F3 processor can bring to a flight controller at time the article was written (as most people who read this article would be concerr about). I don't think there was "mis-information" in my post. And thank you for poin

anyway.

“The F3 also has USB bootloader support. F1 requires uart adaptor = more cost.” – And yet your FC is 3 times the price of a Naze32.

I am sorry if this post caused any impact on your sales (although I doubt there wou any), but I hope you can point out what you think is mistaken in more detail so me anyone who is reading this can learn from it.

DOMINIC CLIFTON

15th December 2015 - 11:49 pm

Hi Oscar,

F3 I2C handling is better since the hardware does more meaning less tim ore time for flight code and other code to run. Samplin

o performance gain when doing integer calculations, s ewrite, which is integer based algorithm.” Not true, the where you got that information from. We generate Core the GCC ARM flag ‘-mcpu=cortex-m4’ which generate he CPU core.

ne on the market they are often at a higher price and g apple, microsoft, sony, etc. R&D time has to be paid fo enerally by the early adopters who want the latest and also reduced as manufacturing processes improve. Th arkets, not just FC’s as I’m sure you’re aware.

Keep up the good work on your blog too, some really good posts. Looking forward to reading more!

Without the help of these guys, those F1, F3 discussion would not even matter.

TIM

14th March 2017 - 4:46 am

Innovation requires incentive. Incentive is usually in the form or monetary gain or t
avoidance of undesirable treatment (Soviet era communist method which is effect
often causes a level of mental stress that stifles novel ingenuity).
In the pharmaceutical industry, R&D is ridiculously expensive since the process fo
creating a drug from start to market is a daunting one. Remove the ability to make
for doing this advances in pharmaceutical technology cease. Not only do they nee
recoup the expense incurred bringing a particular drug to market but also that of th

dea what type of work i'm in but you need not have my
fact, if you don't "buy in" then you're selling out….to
aces governed by political systems that are un-Americ
ine products whether they are medications or flight

ave a good blog. You say it is share knowledge and I h
helping share mine from industry, is this ok? I am EE for many years and programmer with
industrial machinery control experience.
The STMF3 is not held in any respect because it does not fit well in commercial application
ignore. F3 is old now not now and failed because nothing much offered over F1 for perform

Why board also cost so much, F3 max add $2 over F1, yet for F3 hardware over double pri
F1 board.

Myself for acro, FPV and racing F1 only, very low cost and betaflight with CC3D is best no
more.

F4 is needed for doing real navigation. F3 is useless middle ground, I explain. F3 lacks
performance for good Kalman filter at good speed, I have Sparky and disapoint, Sparky 2 i
they learn from big F3 mistake use F4 as can run EKF much faster and much more stable,
problem is taulabs software is very bad but maybe librepilot support for sparky2 which is be
more serious software.

For me very surprising F3 is used by any new board, bad move and maybe they follow spa
without think and make same mistake.

Navigation without good EKF is possible but it will not match EKF base system, everyone s

design hardware, I do not say to knock but you must a
ame, it is true but would not buy F3 FC in 2015, wrong

dly towards you but information all should know to avo
vantage and very many more cost, over double F1 FC.

ut! Your info is really interesting!

I guess the Tornado F3 is still a good buy, which is still under $30.

OSCAR

20th October 2015 - 12:14 am

I think the move to F3 was to gain as much performace without the need f
porting job on the software side, a move to F4 is a big one. also, goodluck
selling the delux SP F3 for 45$
The HW invertors are almost worth it by themselves

MAURO

20th October 2015 - 10:42 pm

you said that “optimal loop time” is 1000, this is not true as this depends on what s
you are using and their real Output Data Rate, witch in many board is limited by th
that use i2c (900 read/s, 2280read/s with fast i2c) instead of SPI (27593read/s).
ted that CF on a F1 use 48% of time on floating point
ow-does-cleanflight-spend-its-time-lets-profile/) and it
a great gain to implement better EKF or PID for exam
d to do, and very hard to test qualitatively against a DC
n a bit higher than max ODR of many sensor (6KHz) c
better result than a EKF, and this seems right from whc
mprovement are given by DCM, see github.com/clean
github.com/cleanflight/cleanflight/pull/1404)
mp to F4 or even better a F7, maybe th package with a

OSCAR

16th November 2015 - 11:20 am

1000 is optimal at the moment if you read the betaflight thread more caref
even you can do it faster with SPI gyro, it’s not the most stable and need a

is the naze rev 6 f3 ?

and is there a F4 base/beta flight for revo/sparky v2

sparky would be interesting since it also has an integrated flash storage on board for blackl

OSCAR

16th October 2015 - 9:38 am

no, it's a f1.

I am not quite sure myself, maybe have a search on the betaflight thread.

ANDREW

17th October 2015 - 9:10 am

maintained by someone else. github.com/sambas/cle

e SP3 and the Dodo. Seems like they are very similar,

her than price)

Is same feature, dodo is clone of SRP but dodo use professional board design and

layout issue.

F3 board no good, stick to F1 with cleanflight and betaflight still many ram left on F

Are you saying the SP3 and the Dodo are no good and it's best to stay wit board?

THELEDMAN

16th October 2015 - 9:47 pm

HI Thomas

I think he just means that F3 boards aren't worth the premium in price.

The SP3 board has layout issues but seems to perform well enough that p like FGA think they're fine to fly with. I know MrSteele flies with the Dodo b admits he sticks with cleanflight 1.9 and controller 1. The only issue i'd se using the SP3 is that it's a double sided board which means there are SM bottom. Means you have less real estate to throw a pc with a naze or single sided board.

nadoF3 is roughly the price of a Naze and gets you ar s native SBUS support.

s on what you need. If you only need 1 UART (in addi with an F1 board like oscar says.

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